Virginia Tech ◆ ECE/CS 5565, Network Architecture and Protocols I ◆ Fall 2024

Project 3: Exploring OSPF with OMNeT++/INET and Wireshark

Introduction

In this project, you will examine Open Shortest Path First (OSPF) routing through simulation with OMNeT++ with the INET framework and examining a packet trace with Wireshark. Your work on this project consists of four phases:

1) Simulate a small network using OSPF version 3 with OMNeT++/INET and examine the behavior of the network during the simulation;
2) Modify the network as specified and verify that operation is correct;
3) Examine (but not in depth) an OSPF version 2 packet trace using Wireshark; and
4) Submit a project report covering your work.

Before starting on the project, read through this assignment to know how work in different parts fits together. Also, review the class syllabus especially sections on “Assessments,” “Grading,” “Late and Missed Work,” “Grading Questions," and “Graduate Academic Integrity.”

Part 1: Simulating the Basic Network

For Part 1, use the following three files that are provided with this assignment.

1) **package.ned** –The network design (NED) file specifies the “firstNet” network shown in Figure 1. Note that the network contains four hosts (Host1 through Host4) and five routers (Router1 through Router5). The network uses both IPv4 and IPv6 but the focus is on IPv6.

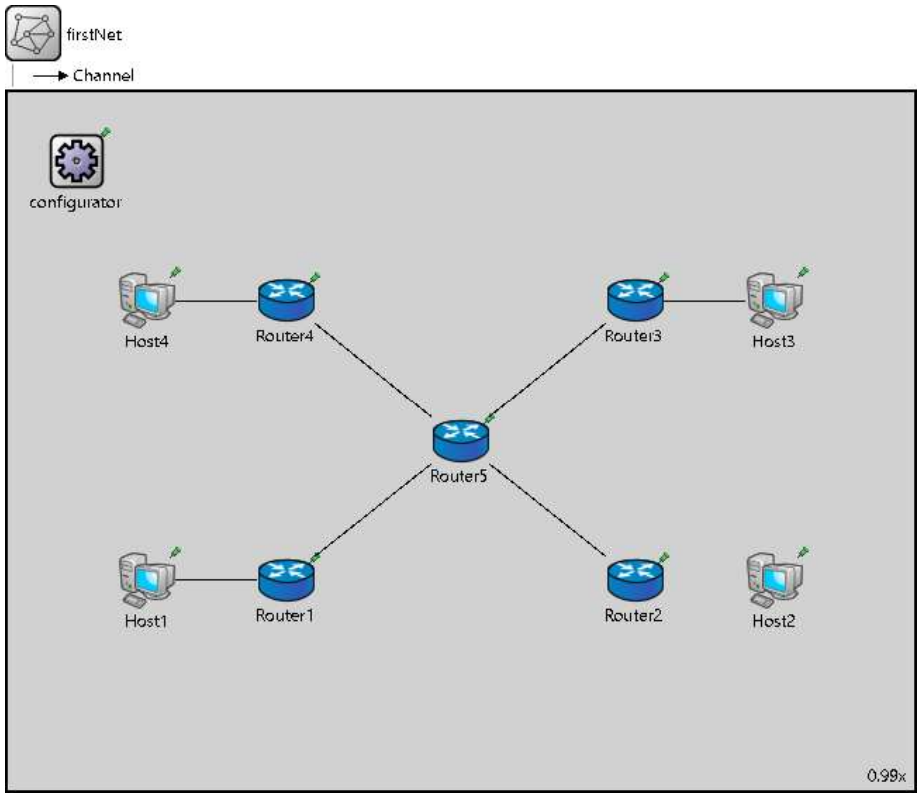

Figure 1. The “firstNet” network for Part 1.

2) **omnetpp.ini** – OMNeT++ initialization (INI) file specifies the OSPF configuration (with details in the config.xml file), applications on Host1 and Host2, and other parameters.
3) **config.xml** – This Extensible Markup Language (XML) file specifies OSPF configurations for the routers and their interfaces.

Study all three files before beginning simulation. Give particular attention to the following topics. Use the Project 3 discussion area on Canvas to ask any questions about the provided code.

- The Ipv4NetworkConfigurator submodule is used for IPv4 configuration. Specifications are provided in the NED file to constrain IPv4 address assignments.
- A generic 100 Mbps channel is used to connect hosts to routers and routers to routers. The `thruputDisplayFormat = "#N"` code in the NED file causes the number of packets sent over each link to be displayed and updated during simulation.
- The INI file specifies a `TcpSessionApp` client running on Host1 and a `TcpEchoApp` server running on Host2. This client-server pair provides the only application traffic in the network. Note that the client application does not start until time = 25s and that 1 MB is transferred from client to server and echoed from server to client.
- Configuration for the routers is contained in the XML file. The INI file specifies this file and the part associated with each router. The key feature in the XML file is IPv6 address assignment. Each router is assigned a router ID and a process ID. All routers use the same process ID, but have different router IDs. Each interface on a router is specified to be in area `0.0.0.0`, so all routers are in the same OSPF area. Each router interface is given an IPv6 link-local address of the form `fe80::a8bb:ccff:fe00:xxx/64` where "`xxx`" varies. Recall that a link-local address only needs to be unique within the same link. Each router interface is also given an IPv6 global unicast address of the form `2001:db8:a:x::x/64` where "`x`" varies. Each link is configured to be its network so the network prefixes differ for each connection in this network.

Question 1.1: Based on your examination of the XML file, complete a table with the specified information. Note that you do not need to consider the "eth1" interfaces for Router1 through Router4. Address entries should include address and prefix notation.

Router	Interface	Link-Local Address	Global Unicast Address
Router1	eth0		
Router2	eth0		
Router3	eth0		
Router4	eth0		
Router5	eth0		
	eth1		
	eth2		
	eth3		

Figure 2. Example of the table to use for Question 1.1.

Question 1.2: Explain how the interfaces connecting Router1 and Router 5 are in a different network than the interfaces connection Router2 and Router5. Be specific.

Next, using the OMNeT++ IDE, create the project (remember to reference INET in the properties as you did for Project 1), build it, and run the simulation. Run the simulation in normal mode (the slow mode) to look at details and then switch to express mode to run the simulation to completion. Verify that 1 MB is transferred in each direction between Host1 and Host2 by looking at the simulation log display. Also, verify the transfer by opening the SCA file in the results, saving the ANF file, and using the Browse Data tab to look at results for both `firstNet.Host1.app[0]` and `firstNet.Host2.app[0]`.

Once you have verified correct operation, run the simulation again. In the log display below the network graphic, select the "Message packet/traffic display" mode. It is the highlighted icon with two dots and two arrows in Figure 3. This will let you examine just the packets being sent and the associated simulation event and time.

Figure 3. OMNeT++ simulation log display mode selection panel.

Run in normal mode for the first 20 seconds or so. You may be able to skip over some of the time using the "Run until time or event number" mode in the simulator. Answer the following questions. You may need to do some background research to learn more about the types of messages being exchanged.

Question 1.3: What is happening during the interval t = 0 to 1 s (approximately) of the simulation? Be sure to briefly describe the purpose of the "NS" messages sent by hosts.

Question 1.4: What is happening during the interval t = 2 to 5 s (approximately) of the simulation? Be sure to briefly describe the purpose of the "RS" and "RA" messages exchanged by the hosts and the routers.

Question 1.5: What is happening during the interval t = 5 to 6 s (approximately) of the simulation? Be sure to briefly describe the purpose of the OSPF Hello messages exchanged by the routers.

Question 1.6: What is happening during the interval t = 15 to 16 s (approximately) of the simulation? Be sure to briefly describe the purpose of the OSPF DD, LSR, LSU, and LSAck messages exchanged by the routers.

Question 1.7: Approximately how often are routers updating each other by sending new OSPF Hello messages? How did you determine this?

Question 1.8: What route is taken between Host 1 and Host 2? How did you determine this?

Question 1.9: Capture an image of the network from the simulator after the simulation completes and include it in your report. The image should show all network components (hosts, routers, and switches) and the display of the final number of packets transferred over each link in the network.

Be sure to run the simulation to completion again and verify that the data transfer was completed.

This completes Part 1 of the project. You will answer the questions from this part as described in Part 4.

Part 2: Building a Modified Network

Create a new project in the OMNeT++ IDE with a network that is identical to the provided network, firstNet, but with Router5 replaced by an Ethernet switch (as used in Project 1). Note the following points in making this change.

- The Ethernet switch should have four interfaces (include `ethg[4]` for the switch in the new NED file). Use the same `Channel` connections from the `eth0` interfaces of the four routers to the switch interfaces. The same connections were used with Router5 in the original network.
- Remove all references to Router5 from the NED, INI, and XML files.
- In the XML file, update the address configurations for Router1 through Router4 so that all four of their `eth0` interfaces are in the same network. The `eth0` interface at each router needs to be assigned a unique link-local and a unique global unicast address. The `eth0` interfaces at the routers should be in the same network.

Using the OMNeT++ IDE, create the project (remember to reference INET), build it, and run the simulation. Run the simulation in normal mode (the slow mode) for to observe details and then switch to express mode to run the simulation to completion. Verify that 1 MB is transferred by looking at the simulation log display. Also, verify the transfer by opening the SCA file in the results, saving the ANF file, and using the Browse Data tab to look at results for both `firstNet.Host1.app[0]` and `firstNet.Host2.app[0]`.

Question 2.1: Export an image of the "Design" view of the NED from the OMNeT++ IDE and include it in the report.

Question 2.2: Specify the link-local and global unicast addresses that are you are using in the modified network. Use a table like what is shown in Figure 4.

Router	Interface	Link-Local Address	Global Unicast Address
Router1	eth0		
Router2	eth0		
Router3	eth0		
Router4	eth0		

Figure 4. Example of the table to use for Question 2.2.

Question 2.3: Include the XML code for Router 1 (and just Router1) in your report. This should include code starting with the `<Router id="Router1">` tag and going through the matching `</Router>` tag from the XML file for the modified network.

Question 2.4: What route is taken between Host 1 and Host 2 in the modified network? How did you determine this?

Question 2.5: Capture an image of the modified network from the simulator after the simulation completes and include it in your report. The image should show all network components (hosts, routers, and switches) and the display of the final number of packets transferred over each link in the network.

This completes Part 2 of the project. You will answer the questions from this part as described in Part 4.

Part 3: Wireshark Analysis

For Part 3, use the provided packet trace file, **OSPFv2.pcapng**.[1] This packet trace contains some different OSPF version 2 messages from a laboratory network.

Open the packet trace file in Wireshark and provide the information specified below.

[1] The OSPF packet trace is from Weberblog.net, https://weberblog.net/ospfv2-capture/ (accessed 10/23/2024).

Question 3.1. Inspect Frame 2 of the trace. Specify: (a) the type of OSPF message; (b) the type of IPv4 addressing used for the message destination; (c) the authoritative router; (d) the network mask; (e) the Hello interval; and (f) and all active neighbors.

Question 3.2. Inspect Frame 9 of the trace. Open the OSPF portion of the frame and the LS Update Packet portion of the OSPF message. Examine the first entry which is labeled "LSA-type 1 (Router-LSA), len 60." Based on this and other parts of the message, specify: (a) the type of OSPF message; (b) the type of IPv4 addressing used for the message destination; and (c) the advertising router.

This completes Part 3 of the project. You will answer the questions from this part as described in Part 4.

Part 4: Submission of the Report

Create and submit a written report with the content described below. Your full name, Virginia Tech PID, Virginia Tech email address, and assignment name ("ECE/CS 5565 Project 3") should appear at the top of the first page. Do *not* include your Student ID number.

Provide answers to all questions above from Part 1 (1.1-1.9), Part 2 (2.1-2.5), and Part 3 (3.1-3.2). In your report, provide four headings. The first three headings for Sections 1, 2, and 3 should correspond to the headings for Parts 1, 2, and 3 in the assignment. Under each section heading, provide answers for the questions from each part of the assignment. Include the question numbers and answer all questions in order. All answers should be concise and clear.

Add a fourth section, "Section 4. Summary." Briefly indicate problems, if any, with the assignment. You must give some information, even if to say you encountered no problems.

Your report should be submitted as a single PDF file with the following file name:

*YourLastName_YourFirstName*_P3.pdf

Note that "YourLastName" is your last or family name as used by Virginia Tech and that "YourFirstName" is your first or given name as used by Virginia Tech. Submit the report in the Assignments section of the class Canvas site by the due date.

Honor System Expectations

Your work on this project and your submission should be your own. You may consult with others about how to use OMNeT++/INET and Wireshark. You are encouraged to ask such questions and provide responses to such questions using the "Project 3" topic in the Discussions section of the class Canvas site. **You are not to collaborate with others on the actual creation of the simulation models and running the simulations required for the project, analyzing results, providing the information for the report, or on writing the report. Such collaboration will be considered a violation of Virginia Tech's Graduate Honor Code.** Please review the section on "Graduate Academic Integrity" in the course syllabus available on the class Canvas site before you begin work on this project.

Grading Rubric

Your project will be graded using the following rubric as a guide. The maximum score is 100 points.

Project Criterion	Attributes of Strong Work	Attributes of Medium Work	Attributes of Weak Work	Maximum Points
Part 1 – Simulation of the first network	All questions are answered correctly and are complete, specific, and concise. The table is complete and correct for 1.1. Explanations are correct and clear. Each type of message is correctly described. The role of each messages is explained. (45-50 points)	There are some minor errors or omissions. There are small errors with the table. Explanations are correct but incomplete or overly verbose. (30-44 points)	There are significant errors or omissions. Multiple explanations are incorrect or vague. (0-29 points)	50
Part 2 – Modification of the network and simulation	Images from the IDE and the simulator are correct and clear. Address assignment in the table is correct. XML code is correct. Explanations are correct clear, and concise. (25-30 points)	There are one or a small number of minor errors with address assignments and the XML code. Images are not fully clear. Explanations are somewhat vague or have minor errors (15-24 points)	There are multiple omissions or other errors with address assignments or the XML code. The table is not clear or has errors. The images are not correct or are unclear. Many of the explanations are incorrect. (0-14 points)	30
Part 3 – Wireshark analysis	All answers are complete, correct, specific, and concise. (9-10) points)	There are a few minor errors or omissions in the answers. (6-8 points)	There are significant errors or omissions. (0-5 points)	10
Overall presentation and submission	Work is clearly presented and organized with headings in the correct order. Text, tables, and images are clear and clearly labeled. The brief summary section is provided. Submission instructions were followed. (9-10 points)	Work is mostly clear but with some lack of clarity in writing, images, and/or tables. Organization is adequate, but not completely aligned with directions given. The summary section is missing. (6-8 points)	Work is hard to follow. Did not follow instructions for organizing the report. Did not fully follow submission instructions. The summary section is missing. (0-5 points)	10
TOTAL POINTS				100

Key References

- OMNeT++ Discrete Event Simulator: https://omnetpp.org/
- INET Framework: https://inet.omnetpp.org/
- Wireshark Network Protocol Analyzer: https://www.wireshark.org/